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(54) Title: NON-STALING BAKED PRODUCTS WITH SUPERIOR NUTRITIONAL QUALITIES

(57) Abstract

A composition of natural ingredients which consists of a milled oat groat product and high gluten wheat flour and may also contain one or more diluents of other natural grain products and methods of utilizing the composition to make both yeast and chemically leavened baked goods which do not stale and have extended keeping qualities, are nutritionally superior due to high protein and dietary fiber content and are reduced in calories; dry mixes of natural ingredients derived from grains from which the yeast or chemically leavened baked goods can be prepared; doughs and batters made by the addition of liquid to the dry mixes; baked goods prepared from the doughs and batters; and the methods of preparation of the mixes, doughs, batters and baked products.

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NON-STALING BAKED PRODUCTS WITH SUPERIOR NUTRITIONAL QUALITIES

BACKGROUND ART

Many and varied efforts have been made to increase the keeping time of bread and other baked goods and to retard the staling process. In connection with these researches and in researches involving nutritional changes, many substances have been added to breads and baked goods with varying results. A detailed look at each of these areas has provided the background for the instant invention.

Staling is a function of starch. It is a process of retrogradation involving the alignment and association of the linear starch molecules, amyloses, over a period of time resulting in firmness and reduction in soluble dextrin, characteristics of stale crumb. During the past century there have been a variety of approaches to the problem of staling. These can be classified into four categories 1) diluents 2) humectants 3) crumb softeners and 4) enzyme removers of amylose. None of these approaches has been successful in eliminating staling in standard baked goods whose principal ingredient is wheat flour. Successes have been limited to delaying by a few days the onset of staling as evidenced by crumb firmness.

Diluents

The earliest attempts to delay staling and increase the keeping time of bread were with diluents of bread flour. The first such attempt used banana pulp. Later inventions utilized amylopectin and Sago flour. Gelatinized corn starch combined with malted barley and cane sugar which combination ferments to produce dextrins as the active additive has also been used as have the higher molecular weight dextrans.

The most recent diluents have been corn flake flour and corn starch or flour obtained from the waxy-sugary 2 genotype ($WxSu_2$) corn, a grain high in amylopectin.

The amount of diluent has ranged from 1% to 30% and the resulting loaves from having a normal bread-like appearance and texture to a starch pudding consistency. The keeping qualities were increased somewhat, but long-term keeping required vacuum packaging and sterilization. These additives increase the water-holding properties and improved the keeping of the breads by water retention, not by retardation of staling. Increased water retention, though it may provide a positive feature from the standpoint of user acceptance, can increase the instance of microbial growth and therefore result in a negative influence on prolonged keeping time.

Humectants

Hydrocolloidal vegetable gums have long been used as humectants or moisturizers in baked goods. These agents take up and hold water in amounts many times their own weight. They are not to be considered anti-stalants though loaves treated with such additives showed greater softness initially and after three to four days when compared to a control. Mixtures of karaya gum, algins and carrageenins have been used.

Crumb Softners

Chemical emulsifiers and surfactants have been shown to increase initial bread softness. These agents include the mono- and diglycerides of fatty acids, esters of diacetyl tartaric acid, propylene glycol and

succinic acid, ethoxylated mono- and diglycerides, polyoxyethylene sorbitan monostearate, sodium stearoyl2 lactylate and calcium stearoyl-2 lactylate. These agents have been found to effect keeping time of bread, but claims of reducing bread staling are not precise. These agents do not reduce the rate of bread staling, using bread firming as the index, but merely increase initial bread softness as the base line upon which subsequent firming is measured. The increased softening of bread treated with this class of additives lends support to the theory that monoglycerides may preferentially bind to the wheat protein.

Enzymes (Removers of Amylose)

Enzymes such as bacterial or fungal amylases have been suggested as anti-stalants. These agents are relatively heat stable and are able to hydrolize the gelatinized amylose fraction in the baking process. When a sufficient number of amylose molecules have been hydrolyzed the molecular alignment potential is reduced and thereby so is staling. The reaction time is critical, excessive action can produce gumminess, and even crumb destruction; too little action, no effect.

The use of heat stable alpha amylase, lesser heat resistant alpha amylase stabilized in sugar solutions and a combination of alpha amylase and pullulanase have been reported.

Enzyme treatment of bread has not been accepted by the commercial baker because of insufficient benefits as compared to the risk of a loss of a commercial run through incorrect usage of the additive and crumb changes in the final product.

NUTRITIONAL CHANGES IN BREAD MAKING

The amount of vital gluten which can be added to wheat flour with a 12.5% gluten content is limited to about 3% of the flour by weight to produce workable doughs and acceptable breads. The use of cellulostic filler to reduce the caloric content of bread has permitted the addition of gluten flour in amounts greater than 5% to increase the total gluten content and the dough strength lost by flour dilution. This concept has resulted in a series of inventions but the breads made using their teachings have not been able to combine caloric reduction with an increased gluten content and still provide a bread capable of being manufactured with existing equipment and have consumer acceptability. Several inventions have also claimed products which have an extended shelf-life, but most for only slightly longer than that for presently marketable baked goods. Where their products have a more extended shelf-life, inventions have required special processing methods or have resulted in a less desirable or unconventional product.

Inventions have alternately utilized alpha cellulose (a wood pulp derivative), microcrystalline cellulose, rice and/or soy hulls, citrus vesicle fibers and wheat bran. Hydrophillic gums have also been used with the cellulostic fillers to produce products with closer resemblances to conventional baked goods.

Breads made using alpha cellulose have the disadvantage of having a higher water content which is detrimental to a prolonged shelf-life. Wood pulp derivatives are not only aesthetically unacceptable, but contain insoluble fiber capable of causing

intestinal dysfunction if used indiscretely and have been prohibited as a food additive in some countries of Europe.

Oat flour has been recognized as a good source of vegetable protein, but the protein is inelastic. However, by blending oat flour with wheat gluten flour in various ratios acceptable breads have resulted. A high protein fraction of oats has been used as a substitute for hydrophillic colloids or gums. The viscous, gum-like characteristic of oatmeal resides with the soluble dietary fiber portion of the oat groat of which the major constituent is beta-D-glucan, a hemicellulose. Beta-D-glucan is present in all oat groat products but oat bran is a particularly good source. The addition of oat products though a successful additive in muffins and cookies has had an inhibitory effect on bread volume and negative effects on bread crumb and texture.

Ideally, a bread enriched with both wheat gluten and oat bran could supply desired levels of protein and dietary fiber for better nutrition and the added effect of lowering serum cholesterol. In addition, increasing the gluten content of bread will (1) reduce the concentration of starch granules in the gluten matrix of the bread and (2) increase loaf volume with a concomitant effect of loaf softness. This has been thought to be the basis of the antifirming effect of increased gluten (protein) content of bread and the reported beneficial effect on staling. It has been found that the staling rate of bread is inversely related to the protein content of the flour. The ratio of starch to protein in the dough was another important factor in determining the rate of bread staling.

Further, the addition of a hydrophillic colloid and small quantities of an oxidizing agent have resulted in a bread having increased loaf volume and improved grain, texture and keeping qualities.

Increasing the gluten content of bread without other additives reduces the firmness associated with staling but has a negative effect on keeping time and on user acceptibility.

Attempts have been made to increase the keeping time of bread by substituting a portion of the water content with a polyhydric alcohol.

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DISCLOSURE OF THE INVENTION

BRIEF SUMMARY OF THE INVENTION

The present invention relates to compositions of natural ingredients, more specifically a milled oat groat product and high gluten wheat flour, and methods of utilizing them to make both yeast and chemically leavened baked goods which do not stale and have extended keeping qualities and are nutritionally superior due to high protein and dietary fiber content. More in particular, the present invention relates to yeast and chemically leavened doughs which are high in protein and dietary fiber, to dry mixes of the said natural products derived from grains which may also contain one or more diluents of other natural grains from which said doughs can be prepared by the addition of liquid, to the products prepared from said doughs by baking and to methods of making such mixes, doughs and baked products, whereby all of said baked products do not stale and have extended keeping qualities.

It is the object of this invention to produce a composition of flours having a high vital gluten content with a higher gluten to starch ratio than standard baking flours. These compositions can be formed, using standard procedures and equipment, into doughs convertible by yeast and/or chemical leavening into breads, rolls, muffins and similar baked goods, which are unique because they resist staling and are capable of having a prolonged shelf-life while avoiding the negative organoleptic properties associated with high gluten-containing baked goods.

It is a further object of this invention to provide baked goods of superior nutritional value due to their high protein and dietary fiber content; more specifically, a high soluble dietary fiber content.

DETAILED DESCRIPTION OF THE INVENTION

Staling of baked goods is of considerable economic importance since it limits the shelf-life to about four (4) days in the store and about equal time in the home. This short shelf-life requires wholesale bakeries to have separate distribution systems operating independently of other packaged food stuffs and limits the distribution area to a maximum radius of distances covered in a 24 hour time span. This makes the staling of baked goods the controlling factor in the operational programming of their manufacture and distribution. The staling process also prevents the stockpiling of such baked goods and prevents their use in such vital areas as disaster relief kits, field packs and mail order distribution.

The shelf-life of such baked goods is that interval from its completed production to the point when, because of feel, taste, odor or appearance, it is no longer acceptable to the user. The length of this interval is dependent upon staling, chemical stability of ingredients, retention of moisture content and maintenance of an acceptable moisture partition, retention of aromatics, maintenance of physical properties, including compressibility and friability (crispness) and contamination with microorganisms. Some of these factors can be managed by selection of ingredients, additives, processing and packaging materials and techniques. The staling process has remained the limiting factor in the prolongation of keeping time or shelf-life. The many approaches to the solution of this problem have thus far failed to provide anything but a few days extension of the shelf-life before the detection of the firming or staling characteristics.

Staling is a function of wheat starch. Although not perfectly understood, it involves the amylose and amylopectin in bread crumb, principally the amylose fraction. Apparently retrograde reactions cause the carbohydrate chains of amylose to associate or align over a period of time generating firmness and reduction in soluble dextrin which characterizes stale crumb.

Wheat flour obtained from the milling of wheat is a combination of starches, gluten proteins and to a lesser extent pentosans, lipids, fiber, vitamins and minerals. The major component is starch, but the gluten in flour, even though present to the extent of about one tenth that of starch, is essential to the making of breads and other leavened baked goods. Gluten, as it develops in the dough forms a chain-like molecular structure which creates an elastic network, trapping the carbon dioxide gas formed during leavening and expanding with it. In addition, this gluten network forms a matrix in which the starch granules are imbedded. Further, the water used to make the dough is held to a large part in the protein matrix. Gluten can take up more than twice the amount of water by weight as does undamaged starch.

As the temperature of the dough rises during baking, the gluten protein is denatured and loses much of its water-holding capacity. Concomitantly, the starch granules absorb water, swell and the starch gelatinizes. Some of the gelantinized starch is released from the swollen and ruptured starch granules to occupy intergranular spaces. Also, the released starch granules can form intermolecular associations which generate the firmness of structure associated with staling. The heat may also cause aggregation of

the amylopectin. This aggregation involves intermolecular association of the side chains of the branched molecules of amylopectin, possibly through hydrogen bonds. Changes within the starch granules, the amylose fraction of starch, and the gluten itself all contribute to the staling process.

Since wheat starch is primarily responsible for the staling process, baked goods have been made of a flour containing wheat gluten in combination with a wheat starch substitute. This combination has produced baked goods capable of being manufactured by standard procedures, able to satisfy user specifications of appearance, flavor, texture, chew and mouth feel, with extended keeping qualities, and which do not stale.

These compositions consist of combinations of wheat gluten flour and one or more of milled oat bran, milled rolled oats or any milled oat groat product containing non-nutritive soluble oat dietary fiber in an amount of from 6.0% to 90.0% but preferably in the amount of from 7.0% to 30.0% of the vital gluten content of the dry mix. The amount of oat groat product used in the dry mix to obtain doughs and final baked products having the desired physical and nutritional characteristics depends further on the non-nutritive soluble dietary fiber content and the particle size of the oat groat material selected. The amount of the wheat gluten flour depends upon its vital gluten content which should not be less than 75% of the wheat gluten flour.

A dilution of vital gluten content below 75% of the wheat gluten flour with one or more of wheat flour, whole wheat flour, wheat bran, rye flour, Miller's bran flour or corn meal flour, while still providing useful

compositions for making either yeast or chemically leavened baked products with the desired resistance to staling and a high nutritional value, create conditions which necessitate the use of a reduced amount of the non-nutritive soluble oat dietary fiber from about 0.2% to 25% of the vital gluten content of the dry mix. The amount of this reduction is directly proportional to the dilution of the vital gluten content. Such dilution of the vital gluten content also necessitates the use of a hydrophillic colloid such as a vegetable gum in the amount of from 0.5% to 3.5% of the dry mix. This addition maintains the hydrophillic colloid content of the mix at about 5% or more of its vital gluten content.

The growing concern about the effects of animal lipids and cholesterol, particularly in the pathogenesis of atherosclerosis and certain cancers and the difficulty of separating animal proteins from their associated saturated fats has increased the need and the search for alternatives to meat. Wheat proteins (gluten) are a valuable source of protein and their nutritional quality can be augmented by the addition of the limiting amino acid l-lysine. Breads and similar baked goods, because of their general use could become excellent food vehicles for wheat protein. In order to make this feasible, the level of gluten in bread would have to be increased by more than two-fold over currently available products. Standard breads, white, rye and whole wheat, contain about 2g of protein per 25g slice (8%). The average hamburger supplies 21g of complete protein and 245 calories. It would take 11 slices of standard bread to supply a similar quantity of protein but with 720 calories. Additionally, most

breads also contain saturated fats to improve texture and to soften the crumb. The protein to saturated fat ratio of some commercial breads is the same as standard hamburger. Since increasing the gluten content of bread reduces user acceptability, gluten bread has all but disappeared from the bakery shelf. Other vegetable protein additives are limited because of their negative effects on bread volume and crumb and therefore, on consumer acceptability.

The use of cellulostic filler to reduce the caloric content of bread has permitted the addition of gluten flour in amounts greater than 5%. This concept has resulted in a series of inventions, but the breads made using their techniques have not been able to combine caloric reduction with an increased gluten content and still provide a bread acceptable to the consumer and capable of being manufactured with existing equipment.

This invention not only provides a baked product with an increased gluten content and a reduction in total calories, but with the additional advantage of high fiber, specifically soluble dietary fiber, and with no saturated fats or cholesterol. These baked products are consumer acceptable and capable of being manufactured with existing methods and equipment.

Such products have far-reaching utility beyond the ordinary consumer and the health conscious, such as for nutritionally deprived people in underdeveloped countries or those subject to natural or war-caused disasters, those on diets which restrict dairy products for the elderly and non-ambulatory where high nutrition and high fiber are essential and for campers, hikers and others whose jobs require long periods in open country.

Non-staling breads may be shipped or transported anywhere no matter how remote, and will arrive in fresh baked condition.

DESCRIPTION OF PREFERRED EMBODIMENTS

The results of the following series of experiments are important to obtain a more detailed description of the present invention. Using a straight-dough method, bread loaves were made from doughs prepared by the addition of salt, yeast nutrient, yeast and water to various flour mixes composed of wheat gluten flour, having a vital gluten content of at least 75% (GF75+) and one of three different oat groat products, oat bran, milled coarsely (overs U.S. # 20), oat bran milled finely (throughs U.S. #40), both of which have a non-nutritive soluble dietary fiber content of 10.5%, or rolled oats, milled finely having a non-nutritive soluble dietary fiber content of 4.8%. After shaping and panning, the loaves were placed in a proofing cabinet at 37°C for 2 hours. They were then baked in an oven at 200°C.

The specific volumes of these loaves after one hour of cooling are inversely proportional to the ratio of oat groat product content to the vital gluten content of the flour mixes from which they are made (Table I column A/D). This relationship is an inverse linear logarithmic function. When the specific volumes of the loaves are made a function of the ratio of the non-nutritive soluble dietary fiber content to the vital gluten content of the flour mixes from which they are made (Table I column B/D), there is no difference in the suppression of loaf volume between the two oat groat products, rolled oats or oat bran, when each are milled to the same fineness (throughs U.S. #40).

Whereas, based upon the same non-nutritive soluble dietary fiber content oat bran, coarsely milled (overs U.S. #20) is less potent in suppressing loaf volume. The relationship of loaf specific volume to the ratio of oat soluble dietary fiber and vital gluten content of the flour mixes is also an inverse linear logarithmic function, paralleling the previously described relationships using oat groat product content. These findings indicate that loaf volume suppression is a direct function of oat soluble dietary fiber content of the oat groat material and an inverse function of its particle size. Further, depending on the particle size of oat groat material used in these experiments, a range of oat non-nutritive soluble dietary fiber in an amount of from 7.0% to 30.0% in the vital gluten content of a flour mix composed of wheat gluten flour (75% or more vital gluten content) and a milled oat groat product will provide a useful range of bread loaf volumes.

The suppression of loaf volume by oat non-nutritive soluble dietary fiber is probably related to the inhibition of gluten strength. The following data will further the understanding of this invention from the standpoint of that inhibition of gluten strength by soluble dietary fiber contained in oat groats or products derived therefrom. If gluten flour with a 75% or greater vital gluten content (GF75+) is admixed with water, yeast and a yeast nutrient such as sucrose, a tough and rubbery doughball is readily formed. This doughball expands with yeast fermentation and continues to expand with baking forming a large ball-like structure which collapses upon cooling. When cut, this ball, with rubbery gluten walls, is hollow, lacking any

of the cellular structure characteristic of bread. This structure could be likened to a collapsed balloon.

Wheat flour with a vital gluten content of approximately 12% can, under the known conditions of bread making, be made into an acceptable bread of varying quality. The addition of GF75+ to this wheat flour will result in changes in the dough and bread which are directly related to the amount of added GF75+. These changes consist of the development of increasingly tough, rubbery doughs difficult to work and after processing, breads with increasing gluten-like characteristics such as open grain with irregular cell networks and gluten strands separating crust and crumb which range from coarse and tough to rubbery. There is a point herein designated the "Saturation Point", when the amount of added GF75+ will exceed the inhibitory effect of the wheat flour on the chemical bonding of the gluten molecules, resulting in a dough and baked loaf having the characteristics of pure GF75+ product described above. In these studies the "Saturation Point" was reached with a wheat starch to vital gluten ratio of 1.2.

Doughs and bread made from mixes of milled oat groat products and gluten flour (GF75+) will show trends similar to those described with wheat flour and gluten flour above, in that as the ratio of oat groat product to vital gluten decreases the dough becomes increasingly tough and non-workable and the bread crumb more gluten-like and rubbery until the "Saturation Point" is reached. Experiments were conducted with milled oat bran (throughs U.S. #40) as a milled oat groat product and GF75+, the results of which show a "Saturation Point" with an oat bran to vital gluten

ratio of 0.24 and a soluble dietary fiber content to vital gluten content of 0.03. Comparing their relative "Saturation Points", this oat bran flour mixture is approximately 5 times more potent than the carbohydrate factor of wheat flour, but based on the non-nutritive soluble dietary fiber content of the oat bran, it is 40 times more potent in inhibiting the chemical bonding of the gluten molecules.

Whereas the "Saturation Point" reflects the gluten capacity of a given flour or the amount of vital gluten which can be assimilated, the amount of vital gluten addition giving workable doughs and acceptable breads is less. The amount of vital gluten which can be added to wheat flour of 12.5% gluten content is limited to about 3% of the flour by weight and the range of ratios of the carbohydrate fraction to vital gluten contents of wheat flour are 4.5 to 7.6 for vital gluten contents of 15.5% to 10% respectively. On the other hand, the range of ratios of oat groat products, based upon their non-nutritive soluble dietary fiber contents, to the vital gluten content of the flour mixes is from 0.05 to 0.60 for vital gluten content of the flour mixes of 46.8% to 15% respectively. Not only do oat groat products have a greater capacity for vital gluten than does the carbohydrate fraction of wheat flour but they also permit a wider range of vital gluten additions while still maintaining the necessary characteristics for workable doughs and acceptable breads. Oat non - nutritive soluble dietary fiber appears to have a dual action, using its effect on bread volume as an index. Specific volumes (y) of loaves made from flour mixes of milled oat groat products (throughs U.S. #40) and gluten flour (GF75+)

having a ratio of soluble dietary fiber to vital gluten content (x) of 0.07 to 0.20 follow the relationship of $y=m\frac{1}{\log x}$ where the slope is (-) 5.8 ± 0.2 indicating a communality of cause and effect. Ratios (x) greater than 0.20 and up to 0.80 produce a lesser rate of specific volume decrease and although the relationship follows that of $y=m\frac{1}{\log x}$ the slope is (-) 1.5 ± 0.06 indicating a decreased potency of the soluble dietary fiber or the introductions of another effect, antagonistic to its weakening effect on gluten. The latter is the more probable and possibly represents the effect of oat soluble dietary fiber acting as a hydrophillic colloid to strengthen the gluten cell network to gas expansion.

Determining the acceptability of a bread suffers from the subjectivity of the process of evaluation. This is complicated by the fact that everyone (gluten sensitive individuals excepted) has lengthy if not diverse experience with bread consumption, and thereby becomes a self proclaimed expert, if not connoisseur. The diversity of bread types but the narrowness of individual experience puts an additional bias on the sensory evaluation of any bread differing from the mass-produced white loaf. Most would not choose a pumpernickel bread over a standard white loaf, although each loaf by itself would be considered acceptable.

There have been efforts made in bread evaluation to use objective measurements such as compression, shred and color indices. However, unless these indices are set to an established norm for a given type of bread they may be of little value or even have a negative value except when used to follow serial changes in similar batches. For example, the compress-

ion index, although used in serial evaluation of bread aging or indirectly, staling, has helped create norms for overly soft, compressible loaves by not measuring rates of change but rather making absolute comparisons between control and treated loaves at given points in time. It should be emphasized that loaf compression is a one dimensional aspect of staling, failing to speak to changes in crumb, texture, slicing characteristics, aroma, taste and mouth sensation. It was for these reasons that an evaluation system was designed to score bread using different categories involving visual, tactile and oral sensations, including taste and aroma. An on/off (yes/no) system is used for most categories, limiting the numerical range from (+) 1 to (-) 1. Where (0) is used, it was decided that the feature or subset would be non-contributory either positively or negatively. In some categories there may be subsets on the positive and/or negative side creating a (+) 2 and/or (-) 2 rating. When there is a (-) 2 in any category the result is sufficiently drastic to score the bread unacceptable. This evaluation method scores a loaf as acceptable (excellent, good, fair) or unacceptable. It does not require a scaled rating within a category, but only the recognition of a subset designation. It is not biased by bread type. It can detect and eliminate stale loaves. Using this bread evaluation system (Table II) the loaves described in Table I were scored. All but the loaves from two mixes were found to be acceptable (excellent, good or fair).

The nutritional advantages of this invention lie in the protein and dietary fiber contents of the flour mixes used in the above experiments (Table III). Breads made from these flour mixes are a rich source of

protein and oat non-nutritive dietary fiber. As an example, two 22.5g slices of a bread made from flour sample #5, (oat bran overs #20), will supply about 12g of protein and 4.9g of non-nutritive dietary fiber, approximately 20% of an adult male's daily requirements of these nutrients. It should be emphasized that the dietary fiber is of oat origin which is particularly important in the management of elevated levels of serum cholesterol. The two slices of the bread mentioned above supply 1.6 times the oat dietary fiber as a serving of oatmeal. If the flour is enriched with l-lysine the protein value of the flour would be enhanced making these breads a valuable source of non-animal protein.

The keeping quality of breads made from the mixes in Table I were evaluated using the Bread Scoring Index (Table II). After baking, the loaves were depanned and cooled at room temperature for one hour. They were placed in polyethylene bags (0.051mm thickness) and closed either with a self closure seal or a metal tie. Based upon crust and slicing characteristics, texture, crumb moistness, aroma, flavor and mouth feel (items # 2,4,8,9,10,11 and 12, Table II) the loaves remained free of staleness at the end of a 30 day period of observation.

Since mold retardants were not used in these flour mixes, mold growth was noted in a large percentage of loaves during the course of the test period. In addition, since there were no special precautions to prevent moisture loss, loaf shrinkage was noted, particularly in the breads made from mixes with vital gluten contents above 40%. Both of these conditions are manageable by techniques known to the art and would not

preclude the possibility of attaining a shelf-life of from several months to two years.

D'Appolonia and Morad (D'Appolonia, B.L., and Morad, M.M., Bread Staling; Bread Chem. 58(3): 186-190, 1981) showed a direct relationship between staling time (3.7 to 11.3 days) and wheat protein content of the flour mix (11.0% to 21.6%). In contrast, the bread loaves made from mixes of GF75+ (gluten flour, 75% vital gluten, minimum) and milled oat groat products and having a varying vital gluten content of from 20.8 to 52.1% (Tables I and III) showed no evidence of staling over the 30 day period of observation. This non-linear response of time constant to protein content of these flour mixes indicates that the combinations of GF75+ and milled oat groat products produce an anti-staling effect in bread which is not directly related to the vital gluten content of the flour mixes and this combination of ingredients has anti-staling properties which are both surprising and unpredictable. Since these various mixes have a 5% or less wheat starch content, the question is then raised as to whether or not the addition of wheat flour in any amount to the combinations of GF75+ and milled oat groat product will alter their anti-staling properties. This was investigated using graded dilutions of the combination of GF75+ and milled oat groat products with all purpose wheat flour (APF) from 10-90% (unadjusted for moisture content) of the mix.

Using a straight-dough method, bread loaves were made from doughs prepared by the addition of salt, yeast nutrient, yeast and water to various flour mixes composed of GF75+ (wheat gluten flour, having a vital gluten content of at least 75%), one of three oat groat

products, oat bran milled coarsely (overs U.S. #20), oat bran milled finely (throughs U.S. #40), both having a non-nutritive soluble dietary fiber content of 10.5%, or rolled oats milled finely (throughs U.S. #40) having a non-nutritive soluble dietary fiber content of 4.8% and all purpose wheat flour (vital gluten content of 12.5%). After shaping and panning, the loaves were placed in a proofing cabinet at 37°C for 2 hours. They were then baked in an oven at 200°C. The specific volumes were measured by volume displacement after one hour of cooling. The data for the finely milled oat bran and rolled oats are presented in Tables IV and V respectively. Results with the coarsely milled oat bran parallel those of the finely milled oat bran except for the effect imposed by the reduced release of non-nutritive soluble dietary fiber from the larger particle size material and therefore are not included here.

It was found that for a given dilution of GF75+ with all purpose flour the ratios of the contents of non-nutritive soluble oat dietary fiber to total vital gluten are inversely proportional to loaf specific volume and the relationship can be described by the function $y=m\frac{1}{\log x}$ where y is the loaf specific volume and x is the ratio of soluble oat dietary fiber to total vital gluten content. The curve parallels the curve developed for milled oat groat products and GF75+ without wheat flour dilution, indicating a similarity of the mode of action of the oat soluble dietary fiber in the two types of mixes (diluted and undiluted). However, the addition of wheat flour to GF75+ potentiates the effect of oat soluble dietary fiber on loaf volume, reducing its requirements and the ratio of

the soluble dietary fiber to total vital gluten content. This reduction in the ratio of soluble oat dietary fiber to total vital gluten content is directly related to the dilution of GF75+ by all purpose wheat flour and for oat bran it can be described by the general equation $y=mx+b$ where y is the ratio of the content of oat soluble dietary fiber to the total vital gluten content of the mix and x is the ratio of the total vital gluten to the all purpose wheat flour content adjusted for its moisture and its vital gluten content (primarily wheat starch), b equals a constant which is less than zero and m is a variable coefficient inversely proportional to the loaf specific volume (S V), described by the equation $SV=a\frac{1}{\log m}$.

When milled rolled oats (throughs U.S. #40) are used instead of oat bran, the reduction in the ratio of the content of soluble oat fiber to the content of total vital gluten of the flour mix necessitated by the dilution of GF75+ by all purpose flour is directly proportional to the amount of that dilution. This relationship is not linear but approximates the general equation $y=m\log x$, where y is the ratio of the content of oat soluble dietary fiber to the total vital gluten content of the mix and x is the ratio of the total vital gluten content to the content of all purpose flour corrected for its moisture and its vital gluten content represented as a percentage and m is a variable coefficient inversely proportional to the loaf volume.

The relationship between the x and y functions between 70% and 90% dilution show a potentiation of loaf volume inhibition by the action of ingredients in wheat flour on the soluble dietary fiber derived from rolled oats similar to that noted for oat bran over the

same range of dilutions with all purpose wheat flour. Lower levels of dilution (10-60%) with wheat flour show a greater potentiation of this gluten inhibiting effect with rolled oats than with oat bran. This would indicate that unlike oat bran there are other components in rolled oats, one of which is oat soluble dietary fiber, which interacts with ingredients in wheat flour to inhibit gluten bonding. No matter the mechanism of action, the dilution of a flour mixture consisting of a milled oat groat product and gluten flour (75% vital gluten, minimally) with a wheat flour, such as all purpose flour, necessitates the use of a reduced amount of non-nutritive soluble oat dietary fiber, from about 0.2 % to 25% of the vital gluten content of the dry mix in order to maintain the required characteristics of the resulting doughs and baked products.

The loaves described in Table IV and V had characteristics of a white wheat flour loaf. Those loaves with specific volumes greater than 5.5 had a more open grain and were more elastic in both resistance to slicing and shred than loaves with specific volumes less than 5.5. Using the Bread Scoring Index (Table II) for evaluation, all loaves were acceptable, ranging between a numerical rating of 12 and 17.

Anti-staling and keeping qualities of bread loaves were evaluated with flour compositions of milled oat bran (throughs U.S. #40) and GF75+ (gluten flour, 75% vital gluten content, minimally) and various dilutions of all purpose wheat flour (vital gluten content 12.5%), the majority being from 60% to 90% of the dry mix, unadjusted for moisture content. Bread was made

from doughs prepared by the straight-dough method. Yeast, yeast nutrient, salt and water were combined with the flour ingredients. After formation, the doughs were divided into 55.5g portions to meet packaging requirements, then shaped and placed in a proofing cabinet at 37°C for 2 hours. Following this, they were baked in an oven at 200°C for 15 minutes. Immediately after baking the small loaves were depanned directly into preformed bags made from polyethylene film (0.051mm thickness). The bags were closed directly with a self-closure seal, or heat sealed. Packaged loaves were stored in open bins at 23°C for periods up to 6 months. Loaves were examined at 1 day after moisture equilibrium, at 5-7 days and 10-18 days after baking and packaging. Thereafter loaves were examined at irregular intervals up to 6 months. Loaves were scored using the Bread Scoring Index (Table II). Only loaves having a score of 13 or more at day 1 were retained for further evaluation.

For periods of up to 60 days of observation loaves made using the range of dilutions with all purpose wheat flour and packaged in sealed polyethylene bags remained soft and compressible and sliced cleanly without crumbling. The crumb was moist and shredded with normal elasticity; aroma and flavor were good. Bread was rated unstaled and acceptable with a score of 11 or better. However, all loaves showed a reduction in the Bread Score Index of 2 points which was due to a transient sensation of dryness with each bite of bread. This was first noted at the 5-7 day period of observation with loaves made using the 80% dilution and as early as one day with the 90% dilution with all purpose wheat flour; and it was additionally observed

in the 10-14 day period of observation with loaves made with 60% and 70% dilutions.

It was found that this sensation of dryness was associated with gluten enrichment of wheat bread and can be perceived as early as day 1 after baking. It is probably related to moisture migration from the protein gel to the starch gel of bread. Its perception is related to the ratio of gluten to starch. It is not a factor in regular wheat flours having a starch to gluten ratio from about 4.5 to 6. As the ratio approaches 4 this transient sensation of dryness is reported. Although noted with the loaves made from the flour mixes containing GF75+ and milled oat groat product diluted with all purpose flour, this dryness showed a delay in its first appearance which was directly related to the amount of oat soluble dietary fiber, a hydrophillic colloid. Since oat soluble dietary fiber is a potent inhibitor of gluten protein bonding, increasing its content without a concomitant increase in vital gluten content results in a reduction in loaf volume and even unsatisfactory loaves.

The addition of guar gum to a composition of flours consisting of GF75+ and milled roll oat (throughs U.S. #40) diluted by all purpose wheat flour (70% by weight) demonstrates that guar gum has significantly less effect on loaf volume (inhibition of gluten protein bonding) than the same amount of oat soluble non-nutritive dietary fiber. The addition of 1.25 parts guar gum to a flour mix consisting of milled rolled oats, GF75+ and all purpose flour increases the soluble fiber content of the flour mixture about 6 times, but the observed effect (actual specific volume) could be produced with about a 2 times increase in oat

soluble dietary fiber. Thus, oat soluble dietary fiber is about 3 times more potent than guar gum in inhibiting gluten protein bonding.

On the other hand, vegetable gums, such as guar gum, take up about 26 times their weight in water, in contrast to oat soluble dietary fiber which takes up about 13 times its weight. Thus, guar gum is about 2 times more potent a hydrophillic colloid as oat soluble dietary fiber. The separation of these two effects, gluten inhibitory and hydrophillic colloidal, in two different directions in the two materials, oat soluble dietary fiber and vegetable gum, offers a means to control the undesirable effects of gluten when combined with other baking flours with the possibility of retaining the desirable features of gluten. A combination of oat soluble dietary fiber and vegetable gum such as guar gum could provide a proper balance between gluten inhibition and hydrophillic colloidal properties to permit at least a 17% vital wheat gluten content in baking flours such as wheat, whole wheat, rye, corn or bran flours or combinations thereof. Breads made from such combinations would exhibit prolonged anti-staling properties and would not produce the unsatisfactory aspects of crumb toughness and dryness characteristic of breads with a starch to gluten ratio of about 4 or less.

The use of vegetable gum by itself in combination with gluten flour in amounts sufficient to alter the keeping quality of bread fails to provide the necessary characteristics for an acceptable bread. Loaves made from a flour with a vital gluten content of about 17% of the dry mix and guar gum in the amount of 1.5% of the dry mix were found to be unacceptable because of

separation of crust and crumb. Similarly, loaves of bread made from a flour mix with a gluten content of about 17% of the dry mix and an oat soluble dietary fiber content of 0.05% of the dry mix were found to be unacceptable because of a dry sensation upon eating and a slight separation of crust and crumb. Surprisingly, loaves of bread made from a flour with a vital gluten content of about 17% of the dry mix, an oat soluble dietary fiber content of 0.04% of the dry mix and guar gum in the amount of 1.5% of the dry mix produced acceptable loaves with a Bread Score Index of 13 or more. Importantly, there was no separation of crust and crumb and a moist sensation when eaten. Rather than being an additive effect to worsen crumb-crust integrity, the combined action of guar gum and oat soluble dietary fiber was to preserve it.

Using a straight-dough method, bread was made from doughs prepared by combining flour mixes consisting in various amounts of milled rolled oats or milled oat bran (throughs U.S. #40), GF75+ (gluten flour, 75% vital gluten content, minimally), all purpose wheat flour (12.5%, vital gluten content) and guar gum (2.5 parts for 100 part of dry mix) with water, yeast, yeast nutrient (sucrose) and salt. In addition, rye loaves were prepared using, in place of all purpose wheat flour, a flour mixture of rye flour and all purpose wheat flour in a ratio of 1/1.6. After the dough was formed it was divided into 55.5g pieces, for convenience of packaging, shaped, proofed for 2 hours at 37°C and baked for 15 minutes at 200°C. Immediately after baking the loaves were depanned directly into bags made of polyethylene film (0.05mm thickness), heat sealed

and stored in open bins at 23°C for up to 4 months. Periodically loaves were examined and evaluated using the "Bread Score Index" (Table II).

The initial evaluation Day 1-3 showed all loaves to be excellent (15-17) except the 90% dilution loaves which showed irregular cellular structure in some loaves. There was a further reduction in the "Bread Score Index" of the 90% dilution beginning in the Day 7 interval. This was attributed to a slight dry sensation with the initial bite. This also developed in the 80% dilution loaves at a later time, the Day 14-17 interval. This was the same phenomenon noted at Day 1-2 in the 90% dilution, day 5-7 in the 80% dilution and day 10-14 in the 60% and 70% dilution loaves not containing guar gum. Thus the guar gum delayed the onset of this dry sensation for about 7 days for the 80% and 90% dilution loaves. The 60% and 70% dilution loaves with guar gum never developed this negative feature. Since the ratio of total soluble fiber content to total vital gluten content for the 80% and 90% dilution loaves was greater than for the 60% and 70% dilution loaves (see Table VI), a soluble dietary fiber content of at least 5% of the vital gluten content is not the complete answer to prolonged keeping qualities. A further examination of the relationships of these flour mixes shows that the 60% and 70% dilution loaves also have a total soluble dietary fiber content of 5% or more of the APF starch content while the 80% and 90% dilution loaves have a total soluble fiber content of less than 5% of the APF starch content, 4.5% and 3.9% respectively. It should be noted that none of these loaves made with mixes of from 60% through 90% dilution were stale. They were com-

pressible, cut cleanly without crumbling, remained moist and did not have a stale taste or give a mouth sensation of staleness. The dry sensation reported here is due to the moisture migration between the protein and the wheat starch gels and can be controlled by the soluble dietary fiber content of the flour mix. The onset of the effect is directly related to the soluble dietary fiber content as a function of both the total vital gluten content and the wheat starch content of the flour mix. In order to have bread loaves with keeping times of 60 days or more, the soluble dietary fiber content (oat soluble fiber and vegetable gum) must be at least 5% of the wheat starch content of the flour mix.

The decrease in "Bread Score Index" in the Day 50-60 interval in the Rolled Oat Series at the 70-90% dilution was due to a perceptible change in aroma from that of fresh wheat bread to a nutty aroma (gluten-like). This was not seen with the 60% dilution loaves. A decrease in "Bread Score Index" was noted also in the Day 14-17 interval for all dilutions (60-90%) in the Oat Bran Series. This was due to a change in flavor from bread-like or grain-like to a sour taste. Finally, those loaves examined at the Day 120 interval showed surface dryness which further reduced the "Bread Score Index".

Polyethylene film (0.05lmm) of which these bread storage bags were made is not impermeable to gas and moisture transmission. The progressive development of the dry sensation, in 7 days in the 90% dilution loaves progressing to surface dryness by the Day 120 interval, is consistent with a decreasing moisture content, not just a moisture migration. The slight changes in

flavor and aroma noted above are consistent with gas transmission and with loss of aromatics either by diffusion from the package or oxidation by oxygen entering the package. Oxidation of other ingredients, gluten flour and oat bran, is known to change flavor under conditions of storage which permit air contact.

MODES FOR CARRYING OUT THE INVENTION

There is a need for a bread with prolonged keeping qualities of one year minimally but preferably two years in order to supply a missing ration for field packs. However, in addition to keeping quality, of which absence of staling is a major factor, there are additional features, not supplied by currently available breads, which should be incorporated into this bread to contribute to its nutritional qualities. These include a high protein, low fat (no animal fat) and high non-nutritive dietary fiber content to improve intestinal function and bowel regulation and reduce dangers associated with high saturated fat and cholesterol intake. Due to these considerations, and based upon the previously described specifications to prevent staling, a flour mix was developed having the following composition:

Ingredients	Parts
Wheat Bran (Miller's Bran - throughs U.S. #40)	105
Oat Bran (throughs U.S. #40)	24
Gluten Flour (Vital Gluten Content 75% "GF75+")	110
Guar Gum	6

To this flour mix the following ingredients were added as flavoring agent:

Ingredients	Parts
Onion Powder	4-8
Carraway Seeds	5-9
Salt	3-5

Since these loaves were intended for packaging in containers resistant to oxygen transmission, with the original environment of the sealed containers being low in oxygen and with no special product sterilization employed, a water activity (Aw) of 0.81 or lower was thought to be essential to prevent microbial growth, particularly the anaerobic variety. In preliminary studies it was found that the use of water alone to form a dough from this flour mix led to a bread having a water activity (Aw) of about 0.85. Substituting a glycerol-in-water solution of one volume glycerol to 9 volumes of water (10% glycerol solution) for plain water in the dough preparation led to bread having an Aw of 0.81 or less with the bread having a water to glycerol ratio of 7 or greater.

6.82 Kilograms ... of the above described flour and flavor ingredients were added to 5.91 liters of glycerol-in-water solution (5.91cc of glycerol in 5.32 liters of water) with the appropriate amount of yeast and formed into a dough (straight-dough method). The dough was divided into 46g pieces, shaped and fit into special pans which would yield a baked piece (mini-loaf, 7.6cm x 5.1cm x 5.1cm) designed to fit into a field ration pack. Following proofing at 36°C for up to 2 hours, the loaves were baked at 200°C for 13-15 minutes. Immediately after baking, the loaves were depanned directly into preformed bags made of an aluminum foil, polyethylene colaminate (0.1 mm thickness). Excess air was expressed and the bags were heat sealed. A partial vacuum was formed upon cooling of the loaves.

The packaged loaves were stored in open bins at about 23°C in an ambient humidity (40-50%) for over two

years. Loaves examined after 27 months of storage remained as fresh and edible as when first baked. There was no staling.

In keeping with the specifications of the invention the vital gluten content was 29.7% of the dry mix and the soluble dietary fiber content, of which oat soluble dietary fiber was a part, was 10.3% of the vital gluten content and 17% of the starch content of the dry mix.

The 40g bread piece would supply 8.4g of protein and 4.8g of dietary fiber, about 12% and 20% respectively of the daily requirements of these nutritional elements. In addition the total fat content was less than 1g of which there was no animal fat.

In addition to the packaging in aluminum foil, polyethylene colaminate bags as above, dough was also put directly into tinned cans for proofing. The cans were closed with a lid but not sealed and placed in an oven at 200°C for 25 minutes. Immediately after baking the lids were sealed and the cans allowed to cool. The canned bread was kept for two years and remained fresh without staling with the same aroma and flavor as when newly baked.

A straight-dough method was used in the above studies as a matter of experimental convenience, but other methods of dough formation can be used including a continuous dough process. These mixes, particularly those from which breads having a specific volume of 5.5 or less are made, closely resemble wheat flour doughs in workability. Similarly, in order to optimally control these experiments and to establish relationships between composition of mixes and the physical, eating

and keeping qualities of the resulting bread, the use of oxidizing agents, conditioners, mold retardants, etc., was avoided. However, the use of such agents in this invention is not precluded and the expected results from their use should be achieved.

Bread loaves and rolls (mini-loaves) were used as the baked goods to evaluate the end points of the above described studies because these products are the most demanding of wheat flour and wheat flour mix performance. Other yeast leavened products such as pizzas, English muffins and bagels have been made using these flours. They are interchangeable as far as product formation is concerned with those made of bread flours having the normal range of vital gluten content.

Chemically leavened formulations have also been made using the flour mixes of this invention. In this regard, the most important are Irish soda bread which differs from regular wheat bread only in the type of leavening agent (baking soda instead of yeast) and Graham bread, which uses graham flour in combination with wheat bread flour. Muffins which employ a modified batter containing shortening and eggs can be made with the various flours of this invention.

EXAMPLE I

Blend

Gluten flour (GF75+)	30g
Oat Bran (throughs U.S. #40)	80g
Baking Powder	15g
Grated Orange Peel	10g
Sugar	50g
Salt	2g

Add

Margarine (melted)	15g

1 egg (beaten)	---
Orange Extract	8cc
Milk	100cc

Mix thoroughly, pour into greased muffin tins and bake at 165°C for 25 minutes.

The resulting muffins have a light texture and excellent mild orange flavor which make them highly acceptable. A fruit muffin may be prepared with the addition of blueberries or pineapple.

Nutritionally one 75g muffin contains:

Protein	11.2g
Fat (Total)	5.0g
(Animal Fat)	(1.2g)
Dietary Fiber (Total)	5.0g
(Oat Soluble Fiber)	(2.1g)

Muffins are less structured than bread or rolls and do not need flours with as great a gluten strength. The above formulation for muffins uses a flour with a ratio of oat soluble dietary fiber to total vital gluten of 0.37. A bread made from this flour would have a specific volume of slightly less than 4, a result consistent with strong gluten inhibition. Similarly if muffins are to be made from a flour in which the GF75+ is diluted by another flour such as an all purpose wheat flour, the ratio of oat soluble dietary fiber to total vital gluten content which should be used is one that would produce a bread with a specific volume of about 4.

EXAMPLE II

Blend

Gluten Flour (GF75+)	50g
Oat Bran (throughs U.S. #40)	50g
All Purpose Flour (vital gluten 12.5%)	50g

Guar Gum	3g
Baking Powder	15g
Grated Orange Peel	10g
Sugar	50g
Salt	2g

Add

Margarine (melted)	15g
1 egg (beaten)	---
Orange Extract	8cc
Milk	100cc

Mix thoroughly, pour into greased muffin tins and bake at 205°C for 17 minutes.

The muffins made as per Example II had an excellent appearance, aroma, texture and flavor. Nutritionally they were equivalent to the GF75+, oat bran flour muffin (Muffin I).

Muffins made with the flour compositions of this invention do not stale and have the potential for prolonged keeping time. However, the use of eggs, milk and polyunsaturated fats in muffins necessitates processing and packaging requirements different from those for bread made in accordance with the invention. Unsaturated vegetable fats are used in the preparation of these muffins because these fats do not have the same potential for cardiovascular and cancer risk as do saturated animal fats. Unsaturated vegetable fats develop rancidity by oxidation with exposure to air. Bakers use lard (saturated animal fat) despite the negative health implications in order to solve the problem of rancidity and maintain a shelf-life specification. This is an unsatisfactory solution, particularly from the stand point of this invention, the object of which in part is to produce a nutritionally

superior baked piece. Reduction or elimination of the oxygen environment in which the baked goods are packaged prevents the development of rancidity of an unsaturated fat. Therefore, the use of packaging materials having a reduced or limited oxygen transmission combined with nitrogen flushing of the package before closure will reduce the possibility of rancidity. In addition, antioxidants, such as Vitamin E offer further protection against rancidity.

Milk and particularly eggs which introduce and support the conditions for microbial growth create a potential problem of safety. The normal baking process does not raise the interior temperature of a baked piece sufficiently to sterilize it. Reduction of the water activity (Aw) below 0.85 lessens the chance of microbial growth but without proven sterilization procedures the risk of bacterial contamination and food toxicity from baked pieces containing eggs and milk packaged under conditions of long term storage with reduced oxygen tensions is too great to permit commercial feasibility. Other than sterilization of the final product, elimination of milk and eggs from batter formulations remains the best option for reducing the risk while still maintaining a reasonable price structure.

Whole eggs contribute to the binding capacity of batter through the action of the albumen of the white and a softening or texturizing effect on the crumb due to the lipid action of the yolk. Milk protein softens the crumb. Both milk and eggs impart flavor and contribute to the protein nutritional value of the product. However, egg yolks because of their high cholesterol and fat contents also have a negative nutritional

effect. Oat soluble non-nutritive dietary fiber possesses unique combinations of properties discoverd in these studies. These are adhesiveness (hydrophilic colloidal property) which permits the development of batters without the use of egg albumin for its binding properties and crumb softening (gluten molecular bonding inhibition) which gives a texturizing effect to the crumb without the use of egg yolk or milk solids.

A flour, composed of oat bran or a similarly milled oat groat product and GF75+ (gluten flour, vital gluten content, 75%+) alone or diluted with another type of baking flour and with the diluent flour a vegetable gum such as guar gum, according to the invention, blended with a chemical leavening agent such as baking powder and/or baking soda and sugar and the combination mixed with vegetable shortening (unsaturated fat) and water forms a batter which upon baking is converted into a muffin having an excellent shape and a moist, soft crumb and with the addition of spices and fruit, such as raisins, a flavor and aroma comparable to a fruit cake.

EXAMPLE III

Blend

Gluten Flour (GF75+)	40g
Oat Bran (throughs U.S. #40)	90g
Baking Powder	10g
Baking Soda	5g
Cinnamon	1g
Allspice	1g
Nutmeg	0.3g
Salt	1g

Add

Brown Sugar	90g

Corn Oil	35g
Water	120cc

Mix thoroughly, pour into greased muffin tins and bake at 200°C for 17 minutes. (Raisins which have been lightly floured may be folded into the batter).

For short term storage, up to 4 weeks, the muffins are depanned immediately after baking into preformed bags made of polyethylene film (0.051mm thickness) which have been flushed with nitrogen gas. The filled bag is then closed by heat sealing. Longer term storage requires a packaging film resistant to gas transmission and the use of glycerol in water solution (1:10) to form the batter. The resulting muffins have a water to glycerol ratio of 6 or greater and an Aw of 0.85 or less.

As previously described the gluten flour (GF75+) component of the flour mix may be diluted with a variety of baking flours such as wheat flour, rye flour, milled corn meal flour, whole wheat flours, wheat bran or milled Miller's bran flour, or combinations thereof. For example, the addition of Miller's Bran and all purpose flour to the GF75+ and oat bran flour in the muffin formula (Example III) was used in Example IV.

EXAMPLE IV

Blend

Gluten Flour (GF75+)	50g
Oat Bran (throughs U.S. #40)	30g
Miller's Bran (throughs U.S. #40)	30g
All Purpose Flour (vital gluten 12.5%)	40g
Guar Gum	3g
Baking Powder	10g
Baking Soda	5g

Cinnamon	1g
Allspice	1g
Nutmeg	0.3g
Salt	1g

Add

Brown Sugar	90g
Corn Oil	35g
Water	120cc

Mix and Bake as in Example III.

TABLE I

THE RELATIONSHIP OF BREAD SPECIFIC VOLUME TO OAT SOLUBLE DIETARY FIBER AND GLUTEN CONTENT

	Exp. #	A* Oat Groat Product	B* Soluble Fiber	C* Gluten Flour GF75+	D* Vital Gluten	A/D	B/D	Number of loaves	Specific Volume cc/g	S.D.
Oat Bran (throughs U.S. #40)	1.	60	6.3	100	75	0.8	0.08	6	6.3	0.28
	2.	86	9.0	114	86	1.0	0.10	6	6.0	0.50
	3.	80	8.4	80	60	1.3	0.14	6	4.9	0.34
	4.	100	10.5	64	48	2.1	0.22	6	4.0	0.21
	5.	100	10.5	100	75	1.3	0.14	1	4.8	----
	6.	120	12.6	80	60	2.0	0.21	1	4.2	----
	7.	140	14.7	60	45	3.1	0.33	1	3.6	----
	8.	160	16.8	40	30	5.3	0.56	1	3.4	----
	9.	162	17.0	29	22	7.4	0.77	1	3.1	----
Oat Bran (overs U.S. #20)	1.	80	8.4	80	60	1.3	0.14	6	6.2	0.27
	2.	90	9.5	70	53	1.7	0.18	6	4.9	0.24
	3.	96	10.1	64	48	2.0	0.21	6	4.9	0.24
	4.	100	10.5	58	44	2.3	0.24	6	4.6	0.21
	5.	108	11.3	52	39	2.8	0.29	6	4.2	0.27
	6.	108	11.3	52	39	2.8	0.29	6	4.0	0.21
Rolled Oats (throughs U.S. #40)	1.	90	4.3	70	53	1.7	0.08	6	6.3	0.45
	2.	100	4.8	55	41	2.4	0.12	6	5.0	0.26
	3.	108	5.2	52	39	2.8	0.13	6	4.7	0.23
	4.	120	5.8	40	30	4.0	0.19	6	4.0	0.23

* all weights measured in grams
S.D.- Standard Deviation

TABLE II

METHOD OF BREAD LOAF EVALUATION USING A BREAD SCORING INDEX*

1. Crust Color

   Carmel Brown (+) 1, Light Brown 0, Other (-) 1

2. Crust Characteristics

   Crusty (+) 1, Soft Crust (+) 1, Dry (-) 1, Wrinkled (-) 2, Deteriorated (-) 2

3. Loaf Shape

   Symmetrical (+) 1, Asymmetrical 0, Shrinkage (-) 1, Collapse (-) 2

4. Slicing Characteristics

   a. Clean (+) 1, Crumbling (-) 1

   b. Resistance (+) 1, Compressible (-) 1, Rigid (-) 2

5. Grain

   Fine (+) 2, Open (+) 1, Dense (-) 1, None (-) 2

6. Cellular Structure

   Uniform (+) 1, Irregular 0, Crust Separation (-) 2, Absent (-) 2

7. Shred

   Elastic (+) 1, Pasty (-) 1, Rubbery (-) 1, Crumbly (-) 2

8. Texture

   Soft, Velvety (+) 2, Soft, Smooth (+) 1, Pasty 0, Coarse, Tough (-) 1, Hard (-) 2

9. Aroma

   Bread-like (+) 1, Flat 0, Off (-) 1, Unpleasant (-) 2

10. Flavor

    Grain-like (+) 1, Flat 0, Off (-) 1, Unpleasant (-) 2

11. Mouth Feel

    a. Moistness — Moist (+) 1, Dry (-) 1

    b. Chew — Chewable (+) 1, Pasty or Soggy (-) 1, Brittle (-) 2

    c. Softness — Soft (+) 1, Chewy or Rubbery (-) 1, Hard (-) 2

    d. Adherence to Mouth Parts — Clean (+) 1, Adherent (-) 1

*SCORING INDEX

EXCELLENT	15-17
GOOD	13-14
FAIR	11-12
UNACCEPTABLE	<11 (A (-) 2 In any category is unacceptable)

TABLE III

PROTEIN AND DIETARY FIBER CONTENT OF THE FLOUR MIXES USED IN TABLE I

	Exp.#	Vital* Gluten	Total* Protein	Dietary* Fiber
Oat Bran (throughs U.S. #40)	1.	52	61	9
	2.	48	57	11
	3.	42	53	12
	4.	33	46	15
	5.	42	53	12
	6.	33	47	15
	7.	25	41	17
	8.	17	35	20
	9.	13	32	21
Oat Bran (overs U.S. #20)	1.	42	53	12
	2.	37	49	14
	3.	33	47	15
	4.	31	45	15
	5.	27	42	17
	6.	27	42	17
Rolled Oats (throughs U.S. #40)	1.	37	46	6
	2.	29	44	7
	3.	27	39	7
	4.	21	34	8

*Per cent by weight of dry mix

TABLE IV

BREAD SPECIFIC VOLUME - A FUNCTION OF
OAT SOLUBLE DIETARY FIBER TO
VITAL GLUTEN CONTENT

Flours composed of milled oat bran (throughs U.S. #40)
and GF75+ diluted with All Purpose Flour

Exp.#	Dilution %	Soluble Fiber / Total Gluten	Total Gluten / Wheat Starch	Specific Vol. cc/g	Std. Dev. (N=6)
1.	90	0.003	0.23	6.4	0.37
2.	90	0.005	0.27	5.6	0.24
3.	80	0.006	0.41	6.4	0.23
4.	80	0.008	0.40	6.0	0.34
5.	70	0.010	0.57	6.4	0.45
6.	70	0.021	0.53	5.1	0.29
7.	50	0.019	1.05	6.2	0.29
8.	40	0.028	1.42	6.0	0.27
9.	30	0.023	2.19	7.2	0.14
10.	20	0.106	2.41	5.3	0.36

TABLE V

BREAD SPECIFIC VOLUME - A FUNCTION OF
OAT SOLUBLE DIETARY FIBER TO
VITAL GLUTEN CONTENT

Flours composed of milled rolled oats (throughs U.S. #40)
and GF75+ diluted with All Purpose Flour

Exp.#	Dilution %	Soluble Fiber / Total Gluten	Total Gluten / Wheat Starch	Specific Vol. cc/g	Std. Dev (N=6)
1.	90	0.002	0.27	5.9	0.24
2.	90	0.005	0.26	5.0	0.23
3.	80	0.007	0.38	6.3	0.41
4.	80	0.010	0.37	6.0	0.25
5.	70	0.011	0.52	6.8	0.22
6.	70	0.015	0.49	6.4	0.21
7.	60	0.015	0.69	6.6	0.48
8.	60	0.019	0.74	6.2	0.19
9.	50	0.016	0.96	6.3	0.13
10.	40	0.019	1.31	6.4	0.33
11.	30	0.026	1.81	6.1	0.29
12.	20	0.043	2.53	5.6	0.20
13.	10	0.074	4.35	5.0	0.29

TABLE VI

KEEPING TIME OF BREAD FROM MIXES OF MILLED OAT GROAT PRODUCT, GF75+, GUAR GUM DILUTED WITH ALL PURPOSE FLOUR

	Exp.#	Dilution %	Soluble Oat Fiber / Total Vital Gluten	Total Soluble Fiber / Total Vital Gluten	Day:	Bread Score Index 1-3	7	14-17	25-35	50-60	75	120
Rolled Oats (throughs U.S. #40)	1.	60	0.012	0.092		15-17	15-17	15-17	-----	15-17	----	----
	2.	70	0.010	0.102		15-17	15-17	-----	-----	13-15	----	13-15
	3.	80	0.006	0.116		15-17	15-17	-----	13-15	11-13	----	unacc.
	4.	90	0.002	0.139		13-15	11-13	-----	-----	9-11	----	unacc.
	5.	60*	0.012	0.097		15-17	15-17	-----	15-17	15-17	15-17	13-15
Oat Bran (throughs U.S. #40)	1.	60	0.023	0.089		15-17	15-17	13-15	-----	13-15	-----	-----
	2.	70	0.013	0.101		15-17	-----	13-15	-----	13-15	-----	-----
	3.	80	0.005	0.109		15-17	-----	13-15	13-15	13-15	-----	-----
	4.	90	0.002	0.136		13-15	-----	11-13	11-13	unacc.		

*Rye Flour/All Purpose Flour (1/1.6)

I Claim:

1. A composition of flours comprising gluten flour in amounts sufficient to produce a content of vital gluten of at least 17% of the dry mix, milled oat groat products in amounts sufficient to produce an oat soluble non-nutritive dietary fiber content of from 0.2% to 90.0% of the vital gluten content of the dry mix and a total hydrophillic colloid content of 5% or more of the vital gluten content of the dry mix, of which the oat soluble non-nutritive dietary fiber represents all or a part.

2. A composition of flours as in Claim 1 comprising gluten flour having a vital gluten content of 75% minimally, milled oat bran (throughs U.S. #40) and/or milled rolled oats (throughs U.S. #40) in amounts sufficient to produce an oat soluble non-nutritive dietary fiber content of from 6% to 60% of the vital gluten content of the dry mix and a total hydrophillic colloid content of 5% or more of the vital gluten content of the dry mix, of which the oat soluble non-nutritive dietary fiber represents the entire amount.

3. A composition of flours as in Claim 1 comprising gluten flour having a vital gluten content of 75% minimally, milled oat bran (overs U.S. #20) and/or milled rolled oats (overs U.S. #20) in amounts sufficient to produce an oat soluble non-nutritive dietary fiber content of from 10% to 90% of the vital gluten content of the dry mix and a total hydrophillic colloid content of 5% or more of the vital gluten content of the dry mix, of which the oat soluble non-nutritive dietary fiber represents the entire amount.

4. A composition of flours as in Claim 1 comprising gluten flour having a vital gluten content of 75%, minimally, diluted with another baking flour, milled oat groat products in amounts sufficient to produce an oat soluble non-nutritive dietary fiber content of from 0.2% to 60.0% of the vital gluten content of the dry mix and a total hydrophillic colloid content composed of both oat soluble non-nutritive dietary fiber and a vegetable gum together in amounts of 5% or more of the vital gluten content of the dry mix, with the vegetable gum having a range of 0.5% to 3.5% of the dry mix.

5. A composition of flours as in Claim 4 wherein the diluting flour is one or a combination of wheat flour, rye flour, milled corn meal flour, whole wheat flour or milled miller's bran flour.

6. A composition of flours as in Claim 4 wherein the vegetable gum is guar gum.

7. A dough prepared by the addition of a liquid and a leavening agent(s) to the composition of flours as in Claim 1.

8. A dough as in Claim 7 wherein the leavening agent is yeast.

9. A dough as in Claim 7 wherein the leavening agent is baking powder and/or baking soda.

10. A dough as in Claim 7 wherein the liquid is water.

11. A dough as in Claim 7 wherein the liquid is a 10% glycerol in water solution.

12. A baked piece prepared by baking a dough as in Claim 8 which has risen through yeast fermentation prior to baking.

13. A baked piece prepared by baking a dough as in Claim 9 which has risen through chemical leavening action prior to and during baking.

14. A baked piece prepared by baking a dough as in Claim 10 which has been leavened.

15. A baked piece prepared by baking a dough as in Claim 11 which has been leavened.

16. A method of making a baked piece which comprises:

preparing a dough as in Claim 7, 8, 9, 10 or 11;

baking the dough;

immediately depanning the baked piece directly into a preformed pouch made of a polymeric film or a polymeric colaminate film;

partially evacuating said pouch or flushing said pouch with nitrogen gas; and

heat sealing said pouch.

17. A batter prepared by the addition of a liquid and a leavening agent(s) to the composition of flours as in Claim 1.

18. A batter as in Claim 17 wherein the leavening agent is baking powder and/or baking soda.

19. A batter as in Claim 17 wherein the liquid is milk and/or eggs.

20. A batter as in Claim 17 wherein the liquid is water.

21. A batter as in Claim 17 wherein the liquid is a 10% glycerol in water solution.

22. A baked piece prepared by baking a batter as in Claim 18 which has risen through chemical leavening action prior to and during baking.

23. A baked piece prepared by baking a batter as in Claim 19 which has been leavened.

24. A baked piece prepared by baking a batter as in Claim 20 which has been leavened.

25. A baked piece prepared by baking a batter as in Claim 21 which has been leavened.

26. A method of making a baked piece which comprises:

preparing a batter as in Claim 17, 18, 19, 20 or 21;

baking the batter;

immediately depanning the baked piece directly into a preformed pouch made of a polymeric film or a polymeric colaminate film;

partially evacuating said pouch or flushing said pouch with nitrogen gas; and

heat sealing said pouch.

[received by the International Bureau
on 17 April 1990 (17.04.90);
original claims 1-26 amended; other claims
unchanged (4 pages)]

1. A composition of flours, characterized by gluten flour present in an amount sufficient to produce a vital gluten content of at least 17% of the dry mix and a milled oat groat product present in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 56.0% of the vital gluten content of the dry mix.

2. The composition of flours as set forth in claim 1, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 8.0% to 56.0% of the vital gluten content of the dry mix.

3. The composition of flour as set forth in claim 1, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 10.6% of the vital gluten content of the dry mix.

4. The composition of flours as set forth in claims 1, 2 or 3, characterized in that the oat groat product includes one or a combination of milled oat bran or milled rolled oats.

5. The composition of flour as set forth in claims 1, 2 or 3, characterized by baking flour present in an amount of from 10% to 90% of the dry mix and a vegetable gum present in an amount of from 0.5% to 3.5% of the dry mix.

6. The composition of flours as set forth in claim 5, characterized in that the baking flour includes one or a combination of wheat flour, rye flour, milled corn meal flour, whole wheat flour or milled miller's bran flour.

7. The composition of flours as set forth in claim 5, characterized in that the vegetable gum is guar gum.

8. The composition of flours as set forth in claims 1, 2, or 3, characterized by a liquid and a leavening agent present in an amount sufficient to provide a dough or batter therefrom.

9. The composition of flours as set forth in claim 8, characterized in that said liquid includes a 10% glycerol in water solution.

10. A baked food item prepared by baking a dough or batter which has risen through yeast fermentation or chemical leavening action, characterized by gluten flour present in an amount sufficient to produce a vital gluten content of at least 17% of the dry mix and a milled oat groat product present in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 56.0% of the vital gluten content of the dry mix, a liquid and a leavening agent present in an amount sufficient to provide said dough or batter therefrom.

11. The baked food item as set forth in claim 10, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 8.0% to 56.0% of the vital gluten content of the dry mix.

12. The baked food item as set forth in claim 10, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 10.6% of the vital gluten content of the dry mix.

13. The baked food item as set forth in claims 10, 11 or 12, characterized by baking flour present in an amount of from 10% to 90% of the dry mix and a vegetable gum present in an amount of from 0.5% to 3.5% of the dry mix.

14. The baked food item as set forth in claim 13, characterized in that the baking flour includes one or a combination of wheat flour, rye flour, milled corn

meal flour, whole wheat flour or milled miller's bran flour.

15. The baked food item as set forth in claims 10, 11 or 12, characterized in that the oat groat product includes one or a combination of milled oat bran or milled rolled oats.

16. A method of making a baked food item, characterized by preparing a dough or batter by mixing gluten flour in an amount sufficient to produce a vital gluten content of at least 17% of the dry mix, a milled oat groat product in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 56.0% of the vital gluten content of the dry mix, a liquid and a leavening agent in an amount sufficient to provide said dough or batter; and baking said dough or batter to form said baked food item.

17. The method as set forth in claim 16, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 8.0% to 56.0% of the vital gluten content of the dry mix.

18. The method as set forth in claim 16, characterized in that said gluten flour has a vital gluten content of 75% minimally and said milled oat groat product is present in an amount sufficient to produce a soluble oat dietary fiber content of from 0.2% to 10.6% of the vital gluten content of the dry mix.

19. The method as set forth in claims 16, 17 or 18, characterized in that the oat groat product includes one or a combination of milled oat bran or milled rolled oats.

20. The method as set forth in claims 16, 17 or 18, characterized by baking flour in an amount of from 10% to 90% of the dry mix and a vegetable gum in an amount ranging of 0.5% to 3.5% of the dry mix.

21. The method as set forth in claim 20, characterized in that the baking flour includes one or a

combination of wheat flour, rye flour, milled corn meal flour, whole wheat flour or milled miller's bran flour.

22. The method as set forth in claims 16, 17 or 18, characterized by sealing said baked food item in a pouch which has been particularly evacuated or flushed with an inert gas.

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US89/05207

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): A21D 13/00

U.S. Cl. 426/62

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
U.S.	426/549, 551, 552, 554, 555, 561, 562, 622, 18, 19, 426/20, 21, 27, 61, 62, 653, 106, 128

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4,395,426 (Fan) 26 July 1983	
X	US, A, 4,769,245 (Farrar) 9 September 1988 (column 2, lines 54-56, column 3, line 5)	16-26
A,P	US, A, 4,824,683 (Hodgson) 25 April 1989	
A	US, A, 224,998 (Dart) 2 March 1880	
A	US, A, 2,355,547 (Musher) 8 August 1944	
A	US, A, 1,946,940 (Epstein) 3 July 1934	
A	US, A, 4,587,126 (Patton) 6 May 1986	
A	US, A, 2,487,069 (Musher) 8 November 1949	
A	US, A, 2,355,030 (Musher) 1 August 1944	
A	US, A, 2,355,028 (Musher) 1 August 1944	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search

27 JAN 1990

Date of Mailing of this International Search Report

23 FEB 1990

International Searching Authority

ISA/US

Signature of Authorized Officer

Carolyn Paden

CAROLYN PADEN

Form PCT/ISA/210 (second sheet) (Rev.11-87)

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 3,497,360 (Schaefer) 24 February 1970	
A	US, A, 3,407,078 (Schlichter) 22 October 1968	
A	US, A, 4,357,356 (Joulin) 02 Nov. 1982	
A	US, A, 3,574,634 (Singer) 13 April 1971	
A	US, A, 4,109,018 (Thompson) 22 August 1978	
A	US, A, 3,362,829 (Landfried) 9 January 1968	
A	US, A, 4,604,289 (Spanier) 5 August 1986	

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [1]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers , because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers , because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

3. ☐ Claim numbers_____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 6.4(a).

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [2]

This International Searching Authority found multiple inventions in this international application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority did not invite payment of any additional fee.

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.